What drives interbank loans? Evidence from Canada

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Abstract

We analyse the drivers of the Canadian interbank market using a novel dataset of uncollateralised and collateralised overnight loans, and applying a Bayesian model averaging approach to deal with model uncertainty. We find three important classes of drivers of the terms of interbank loans: (i) the price of substitutes, (ii) financial stress, and (iii) systemic liquidity needs. These drivers have a heterogeneous impact on interbank loans, depending on the collateral quality. We then present the results of a structural VAR analysis, which shows a persistent impact of financial stress and systemic liquidity shocks on the overnight interbank funding market.

Keywords: Interbank lending, repurchase agreements (repos).

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1 Introduction

The importance of interbank markets in helping financial institutions meet temporary liquidity needs has long been recognised in the literature.[1] These markets help redistribute cash from institutions with a surplus to those with a deficit, and thus help the financial sector hedge idiosyncratic liquidity shocks.[2] As highlighted by the recent financial crisis in the United States, disruptions in interbank markets can have significant consequences to the real economy.[3]

The term 'interbank markets' usually refers to transactions motivated by short-term liquidity needs. This includes trades in a variety of instruments such as unsecured loans; repurchase agreements (repos); interest-rate forwards, futures and swaps; foreign-currency swaps; bank certificates of deposit; and commercial paper (Hartmann et al. (2001)). Many of these trades are conducted bilaterally (Ashcraft and Duffie (2007)), which limits the amount of data gathered on, and consequently, the empirical study of, these markets.

The financial crisis – by highlighting the critical function played by interbank lending – spurred efforts to gather data on, and analyse, two particularly important contracts: repos and unsecured loans. A significant body of work has developed around the role played by these markets in the origination and propagation of systemic financial shocks. Other studies have studied the extraordinary liquidity provision by central banks on the interbank market (see, e.g., Allen et al. (2009) and Brunetti et al. (2011)). Yet other studies have attempted to explain the heterogeneous impact of liquidity shocks on the different participants in the financial system by focusing on the role of relationship lending (Cocco et al. (2009), Iori et al. (2008), Craig and Von Peter (2014), etc.).

In this paper, we use weekly uncollateralised lending and repo data in Canada from September 2009 to December 2015 to investigate the determinants of the terms of trade, viz., volume, rate, and haircut, in the overnight interbank market. The terms of trade are

[1]The source of the temporary liquidity shocks are typically interpreted as unanticpated withdrawals by clients facing cash needs. These clients could be retail investors (e.g., in Ho and Saunders (1985), Allen and Gale (2000) and Freixas et al. (2000)), asset managers facing outflows (Chernenko and Sunderam (2014)), or investors facing margin calls on their existing positions (Brunnermeier (2009)).

[2]The provision of central bank liquidity is intended to counter the effect of aggregate liquidity shocks. However, even in such a case, frictions in the interbank market can prevent an efficient reallocation of the additional liquidity thus provided (Heider et al. (2015), Acharya et al. (2012) and Repullo (2005) are amongst many papers that discuss frictions in interbank markets).

[3]Ritz and Walther (2015) model the response of commercial banks to increased interbank market uncertainty, and conclude that lending volumes would be expected to decrease. Iyer et al. (2014) show that interbank lending dry-ups reduce bank credit using data from Portugal; Cingano et al. (2016) show the same effect in Italy. Chodorow-Reich (2014) provides evidence for interbank market frictions affecting employment at small and medium firms in the U.S.

likely to depend on the collateral being posted. Thus, we analyse overnight interbank loans for uncollateralized lending and collateralized lending for the three major collateral types in Canada - repos backed by Government of Canada (GoC) securities, Canadian Mortgage Bonds (CMB), and bonds issued by the Canadian provinces (PRV).[4]

There is little agreement in the literature about the set of variables driving this market. We therefore begin by collecting the broadest possible set of variables spanning the following categories: liquidity indicators, substitute market prices, economic and financial uncertainty indicators, financial stress indicators, macroeconomic variables, and term premia in the bond and foreign-exchange markets. To account for model uncertainty, we use a Bayesian model averaging (BMA) approach, and identify the key drivers of the repo market among this large set of explanatory variables.

We find that (i) the price of substitute sources of liquidity, (ii) proxies for financial uncertainty and financial stress, and (iii) indicators of systemic liquidity needs are the key drivers of the interbank lending market. We also interpret our results as being consistent with the following hypotheses. First, repos are used to meet anticipated, while uncollateralised loans are principally used to meet unexpected, liquidity needs. Second, both rates and haircuts for repos using the riskier collateral (CMB and PRV) incorporate a credit-risk component. Third, repo volumes against all collateral types decrease in response to lower systemic liquidity needs. Fourth, borrowing against riskier collateral becomes more expensive in times of financial uncertainty and financial stress. Fifth, even though lenders seek to incentivise the posting of collateral (by reducing the haircut) in periods of financial stress, borrowers prefer uncollateralised loans even at the cost of paying a higher interest rate.

We supplement this with a structural VAR analysis to determine whether the effects uncovered in the cross-sectional BMA analysis are temporary or persistent and to provide a quantitative assessment of the channels of transmission of the different drivers of the repo market. To this end, we run bivariate structural VARs on the terms of trade of interbank loan type separately with one proxy each of the key drivers identified in the BMA analysis – financial uncertainty, financial stress, and systemic liquidity needs.[5] We find that the effects described earlier are persistent, lasting in many cases up to twenty-five weeks after the initial change in the drivers. This suggests that participants in the interbank market

[4]The terms of individual loans would also depend on the characteristics of the borrower and lender. However, our data do not include the counterparties involved in these trades. We therefore analyse aggregate statistics by collateral type.

[5]As described later, the limited size of our sample prevents us from running the more appropriate multivariate VAR analysis.

potentially face adjustment costs (such as for adjusting the portfolio of collateral held) that prevent an immediate shift to the new steady state after a shock.

This paper is most closely related to the literature that focuses on the effect of institutional arrangements and collateral types on the repo market. Gorton and Metrick (2012) show that in the United States, repos backed by the safest collateral suffered little during the crisis. Mancini et al. (2016) present evidence that repos backed by safe assets in fact acted as a "shock-absorber" in that the volume repos backed by German government bonds increased post the crisis. Krishnamurthy et al. (2014) find that unlike bilateral repos, triparty repo volumes did not undergo a similarly sharp contraction. Afonso et al. (2011) argue that the collateralised market during the crisis suffered due to the expectation of heightened counterparty uncertainty, but still continued to function as a provider of liquidity. We study the interbank loan market in Canada, which during our sample period was mostly driven by over-the-counter trades.

This paper also provides an example of an application of the Bayesian Model Averaging technique that has been used extensively in the literature. Examples include its use in uncovering the determinants of economic growth (e.g., Sala-I-Martin et al. (2004), Fernandez et al. (2001), Rockey and Temple (2016)), corporate default (González-Aguado and Moral-Benito (2013)), and foreign direct investment Blonigen and Piger (2014).

The rest of the paper is organised as follows. We begin with a brief description of the Canadian interbank market in Section 2, and then describe the data we use in Section 3. We then present the econometric framework, before discussing the cross-sectional results in Section 5. Section 6 presents the results of the dynamic analysis of the interbank market. Section 7 concludes.

2 The Canadian interbank market

Access to cash at short notice is a fundamental requirement for a well-functioning financial sector. Financial market participants may wish to cover unanticipated cash withdrawals by clients, face margin calls due to change in the market prices, or may need cash to take advantage of trading opportunities. Such temporary needs for liquidity are typically fulfilled using short-term loans from other financial institutions with surplus cash. Lenders seek to mitigate counterparty risk either by requiring borrowers to post collateral (using repos or securities lending contracts), or by transacting with trusted market participants (typically using the payment infrastructure).

Financial institutions that are required to maintain reserves with a central bank are usually provided access to the payments network to be able to exchange large-value payments with other such institutions. This specialised payments system (e.g., FedWire in the United States and LVTS in Canada) which allows participants to quickly process payments of significant size between one another, is also used for uncollateralised lending. Uncollateralised loans have to be inferred from the payments data, since participants in the system do not indicate the nature or purpose of the payments requests submitted to the payments network. Furfine (1999) used the idea that an overnight uncollateralised loan consists of a pair of payments – from the lender to the borrower on a day, and in the reverse direction for an amount equal to the principal and interst payment the following trading day. Our data on uncollateralised loans come from Rempel (2016), who applies an augmented version of the Furfine (1999) algorithm to Canada's real-time gross settlement payments system, the Large Value Transfer System.

The lender usually demands compensation, in the form of higher interest rates, for the credit risk underlying uncollateralised loans. Borrowers could alternately use the repos, which are in effect collateralised loans, to reduce this cost. Repos are governed by a standard agreement, whose most important feature is the ringfencing of the collateral upon borrower default. In effect, this provision allows the lender to take possession of the collateral, and perhaps sell it to recover cash, without needing to participate in the borrower's bankruptcy proceedings.

Repos in Canada are largely arranged bilaterally, although some repos are traded on inter-dealer broker (IDB) operated electronic platforms open during pre-specified intervals during the day.[6] Beginning 2012, Canada's central counterparty, the Canadian Derivatives Clearing Corporation (CDCC), began clearing repos. Trades cleared by CDCC are first negotiated bilaterally, or through the IDB screens, and then routed to CDCC for novation and netting (across spot, futures, and repo trades). All repo transactions, whether traded bilaterally or centrally cleared, settle through CDSX, the settlement system of the TMX Group (see Garriott and Gray (2016)).

The institutional arrangement in Canada contrasts with that in the U.S., where repos can be arranged both bilaterally and through the Tri-Party repo network. As described by Krishnamurthy et al. (2014), the Tri-Party infrastructure is used mainly by money-market

[6]As described by Garriott and Gray (2016), who provide a detailed description of the infrastructure and participants in the Canadian repo market, IDB repos are characterised by anonymity of the counterparties involved before execution. The IDBs may reveal the counterparties to each other before executing the trade. In some cases, the counterparties may even choose to modify the terms of trade after their identities are revealed.

mutual funds (MMFs) to find safe, short-term returns for their cash holdings. Tri-Party agents provide the MMFs services such as counterparty risk evaluation, and collateral valuation and margining.

In Canada, repo transactions are actually sell/buyback agreements. These agreements slightly differ from the classic repo in that the securities are sold (first leg) and bought back (second leg) at different prices. The difference reflects the interest accrued on the sell/buyback and any cash flows (interim coupons of the underlying bond) that occur during the term of the agreement. Accordingly, the sale and repurchase legs of a repo are settled in CDSX as two separate cash-for-security trades, with the first and second legs having different settlement dates.

Using these two transactions, we recover the underlying repo using a matching algorithm. In essence, the matching algorithm takes advantage of the fact that both legs of a repo involve an exchange of an equal par value of the same security, that these two trades are entered into the CDSX system 'not too far apart' in time, and that the first leg of the repo settles on a date prior to the second.[7] We augment these repos using similarly matched data from the central central counterparty, CDCC. The output of the algorithm is a set of repos with information on the collateral, quantity, repo rate and tenor.

We estimate the haircut applied to the collateral by comparing the price at which the first leg of the repo was settled with the price of the spot trade closest in entry time in the same security.[8]

We use repo and uncollateralised lending data in our analysis. Given the lack of transaction-level securities lending data, we are unable to identify potential short-term lending using securities lending contracts. The concern that our estimates of interbank lending are biased downwards are mitigated by the fact that over 85% of securities lending

[7]The final repo data matches about 60% (by volume) of security-for-cash trades identified as being possible first legs of a repo. The non-matched trades may be because our algorithm is not designed to identify forward, open term, evergreen, or floating-rate repos (see Garriott and Gray (2016) for a description of such repos). There could also be omissions arising from the assumptions made in the matching algorithm (treated in detail in Bulusu and Gungor (2017)). However, since it is unlikely that the errors induced by our algorithm are systematically correlated with security characteristics, we believe that the data are representative of the Canadian repo market.

[8]The estimated haircuts may suffer from estimation errors to the extent that the closest-in-time spot trade is not representative of the base price off which the haircut was calculated. This could be because the difference between entry times of the spot and repo transactions is sufficiently large for the base price to have changed. Alternately, it could be because the price of the closest-in-time spot trade was not representative of the price at which the two counterparties would have traded the same security in the spot market, for example, because the spot trade was 'too large/small', or because it was conducted between parties of different credit risk or bargaining power. To account for possibly large errors, we set repos with estimated haircuts over 25% or below -5% to 'missing'.

trades in Canada are collateralised by other securities. Further, securities lending contracts are typically open-ended, and have a duration longer than one day, which is the focus of our analysis in this paper.

Figure 1 plots the time series of the variables that we study. Panel A plots the average daily volume of interbank lending for each week in the sample for the different collateral types. It is clear that uncollateralised loans and GoC repos dominate the interbank loan market in Canada. GoC repos make up about 45% of the total interbank loan market, while uncollateralised loans form about 35% of the total volume. The share of CMB repo volumes rose from negligible at the beginning of the sample, to fluctuate between 10% and 30%. Provincial repos have taken an increasing share of the total interbank lending, and peaked at about 15% towards the end of the sample. Panel B shows the evolution of the spread of the different rates over the Bank of Canada overnight target. Surprisingly, uncollateralised lending is systematically cheaper than collateralised lending in Canada, to the tune of between five and 10 bps.[9] Among collateralised loans, repos backed by provincial government bonds are on the average more expensive than those backed by CMBs, with GoC repos the least expensive. Panel C plots the haircuts applied to the different collateral types. As would be expected, the haircut applied varies inversely with the perceived safety of the collateral class.

3 Dataset

Our sample consists of transaction-level data on repurchase agreements and daily aggregates of uncollateralised loans in Canada between 28 August 2009 and 31 December 2015. The following information is available for each repo trade: par value and identifier (ISIN) of collateral posted; and repo rate, term and haircut.[10] The total daily quantity of uncollateralised overnight loans along with the weighted-average interest rate – estimated by applying the Furfine (1999) algorithm to interbank payments data – was provided by Rempel (2016).

We restrict our attention to overnight repos, which constitute over 80% of repos by volume in Canada. As described in Bulusu and Gungor (2017), repos could either be motivated by financial market participants looking to borrow cash, or by those seeking

[9]The lower cost of uncollateralised – when compared to collateralised – lending is observed both in the U.S. and in Canada. Rivadeneyra and Rempel (2017) suggest a possible mechanism that generates this seemingly puzzling result.

[10]See Bulusu and Gungor (2017) for a detailed description of the data.

to take (temporary) possession of a specific security for hedging, speculation, or market-making. Since our transaction-level data do not indicate the motive of the trade, we use the repo rate as an indicator. Since the interest paid on the cash lent is lower when highly-sought-after bonds are offered as collateral (see Duffie (1996)), we identify interbank loans as those repos with rates "close to" the overnight target. The rest we classify as trades driven by the search for specific securities, and consequently exclude from our analysis of interbank loans.

In order to include as large a set of determinants of overnight interbank lending as possible, we begin by aggregating the dependent variable to the weekly frequency. To account for differences in the number of trading days in a week, we calculate the average daily volume, rate and haircut per week taking into account the number of trading days in each week. We estimate the daily averages separately by collateral type, focusing on the three most popular collateral classes – Government of Canada bills and bonds, Canada Housing Bonds, and bills and bonds issued by Provincial governments in Canada.[11]

The large literature on short-term interbank funding markets has focused on the importance of financial market conditions in determining the terms of trade. Allen et al. (2009), Caballero and Krishnamurthy (2008) and Moreira and Savov (2016) argue that aggregate demand for liquidity increases with asset price volatility. Heider et al. (2015) highlight the importance of market uncertainty in determining the level of interbank lending. Gorton and Metrick (2012) find that proxies for counterparty risk are strongly related to repo rates and haircuts. We therefore include a large set of variables that capture financial market conditions along three broad dimensions – financial stress indicators, proxies for economic and financial uncertainty, and term premia in various markets. (See Table 1 for the variable descriptions and their sources.)

Gorton et al. (2012) highlights the role of substitute safe assets in the provision of liquidity to the financial system. We accordingly include variables reflecting the cost of substitute sources, viz., bank deposits, Commercial Paper, Bankers' Acceptances, and corporate bonds.[12] Since the use of substitutes is known to vary over the business cycle (see Adrian and Shin (2008)), we also include the few macroeconomic indicators that are available at the weekly frequency.

The extraordinary efforts undertaken by central banks since the great financial crisis have spurred efforts to measure the impact of such policies on interbank lending. Given the

[11]We ignore the other bond classes (such as corporate bonds, Bankers' Acceptances, Commercial Paper) which are used as collateral for less than 5% of total repo volume in our sample. Further, such repos are not traded regularly, which would create data gaps if included in the sample.

[12]Weekly data on the stock of the substitutes are unavailable.

broad agreement about the influence of such liquidity provision in the literature (see, e.g., Fleming et al. (2010), Fleming (2012) and Giannone et al. (2012)), we include the actions of the Government of Canada and the Bank of Canada that could affect the interbank market. In all the analyses that follow, we control for trend, and week-of-the-year, month-of-the-year and quarter-of-the-year effects, given the strong evidence of seasonality in the financial system's demand for liquidity (Bindseil et al. (2003) and Gomis-Porqueras and Smith (2003)).

While we attempt to obtain all possible variables from Canada that fall into the different classes of drivers described above, limitations on data availability force us to turn to corresponding variables in Canada's largest trading partner, the United States, for supplements. As a small open economy, the influence of the United States' economy in general, and financial sector in particular, on Canada is significant.

In all, our sample consists of 50 variables at a weekly frequency from September 2009 to December 2015, including the trend and seasonality controls, and the funding volume, rate and haircut for each week by collateral type to control for the effects of the size of overnight interbank loans. The dependent variables are the uncollateralised loan volume and rate, and the repo volume, rate and haircut for each of the three classes of collateral.

4 Econometric framework

Empirical works on the determinants of interbank lending are scarce, typically due to the lack of data on these markets. Furthermore, the theoretical literature offers only limited guidance on which variables to include in an empirical model of the interbank lending market. Hence, there remains a substantial degree of uncertainty regarding the drivers of this market.

To deal with model uncertainty, in our empirical application, we consider a large number of predictors $\mathbf{X}$ ($K = 50$) to explain the terms of trade of interbank loans (loan volume, lending rate, and, for collateralised loans, the haircuts applied), which leads to potentially 2^{50} candidate models for each dependent variable.[13] Further, our unique dataset of uncollateralised and collateralised lending in Canada allows us to explore possible heterogeneous responses in the sub-markets to the dependent variables we consider.

[13] Of these 50 variables, four variables control for time trends, and weekly, monthly, and quarterly seasonality. A further 12 variables are used to control for potential autocorrelation in the terms of trade - the lagged volume, rate and haircut for repos of each collateral type; the lagged volume and rate of uncollateralised lending; and the weighted average overall interbank lending rate. The remaining 34 variables (described in Table 1) are drawn from outside the repo and uncollateralised loan markets.

Bayesian model averaging (BMA) techniques can conveniently deal with model uncertainty in that this avoids presenting the results based on a single empirical specification, which is considered as known.[14] Given the very large number of candidate models, we rely on an algorithm that only explores a subset of suitable models denoted as MC^3, which consists of an extension of Markov-chain Monte-Carlo (MCMC) methods. Generally speaking, MCMC methods allow one to draw from the posterior distribution of the parameters, and MC^3 takes draws from the posterior distribution of models (see, e.g., the textbook treatment in Chapter 11 of Koop (2003) for additional details). As a result, this means that the BMA algorithm we use will not explore every possible candidate model, but instead concentrate on the models with high posterior model probability.

The general econometric specification we consider is given by

$$Y = \alpha + \mathbf{X}\beta + \epsilon, \tag{1}$$

where $\epsilon \sim N(0, \sigma^2 I_T)$. $Y = (y_1, ..., y_T)'$ and ϵ are $T \times 1$ vectors of the dependent variable and the random shocks, respectively. $\mathbf{X}$ is a $T \times K$ matrix of regressors that may or may not be included in the model, and β is a $K \times 1$ vector that contains the parameters to be estimated. The dependent variable Y indicates the log repo volume, repo rate or repo haircut for one of the four following categories: uncollateralized lending, repo operations using GoC as collateral, repo operations using Provincial bonds as collateral and repo operations using Housing bonds. The matrix of explanatory variables $\mathbf{X}$ includes n predictors among the K predictors listed in Table 1, and the 12 lagged interbank lending market variables described above.

A few additional comments are required. First, we use a Normal-Gamma natural conjugate prior for the model parameters; hence, analytical results for the posterior moments exist. As such, this makes the estimation of a specific model straightforward, which is appealing given the computational burdens of BMA. Given that we have many explanatory variables that are likely to have no effect on the dependent variable, we center the prior for β around 0. We choose a *g-prior* for the variance of β and we follow Fernandez et al. (2001) to set g.[15]

[14] Admittedly, while BMA techniques are suitable to perform model selection (i.e., decide which variables should be included in an empirical model); model uncertainty related to the functional form of the model or the distributional choices for the residuals are not explicitly addressed by standard BMA techniques.

[15] In detail, g is set as

$$g = \begin{cases} \frac{1}{K^2}, & \text{if } N \leq K^2. \\ \frac{1}{N}, & \text{otherwise.} \end{cases}$$

where N indicates the total sample size.

All MC^3 results are based on sampling 26 million draws, and we discard the first 1 million draws to ensure convergence of the algorithm. Hence, all results are presented using 25 million draws. Sequential runs of the algorithm led to virtually identical results, providing evidence in favor of convergence of the algorithm.

5 Empirical results

Table 2 shows the results. As discussed previously, a majority of the explanatory variables are drawn from the United States due to the lack of high-frequency (weekly) data for corresponding variables in Canada. This choice mitigates the possibility of reverse-causality, i.e., liquidity provision in the Canadian interbank market is unlikely to have significant consequences for the real and financial sector in the United States. However, to further alleviate endogeneity concerns, especially involving explanatory variables drawn from Canada, all the explanatory variables are lagged by one period.

For each variable, we report the posterior inclusion probability (pip), posterior mean, posterior standard deviation and the ratio of the posterior mean to the posterior standard deviation. Following Kass and Raftery (1995), we adopt the following rule of thumb for interpreting our BMA results: if the pip lies between 50%–75%, 75%–95%, 95%–99% or is greater than 99%, we interpret the evidence of a regressor having an effect as weak, positive, strong, or decisive, respectively. Moreover, as in frequentist inference, a ratio of the posterior mean to the posterior standard deviation higher than 2 indicates an approximate 95% Bayesian coverage region that excludes zero.

5.1 Determinants of lending volumes

The first column of Table 2 contains the results of the determinants of trading volume, reported for a subset of the explanatory variables used, for the different categories of lending in the panels. Broadly, the results can be summarised as follows: (i) collateralised lending is largely used to cover anticipated liquidity needs, while uncollateralised loans are used to meet unexpected needs for cash, (ii) the volume of lending against a particular collateral type decreases when substitute liquidity sources are cheaper, and (iii) the amount of collateralised lending falls with a decrease in the overall liquidity needs of the financial system. We now describe the evidence for these claims.

The volume of overnight lending is dependent on the liquidity needs of the financial sector, which is expected to show a large degree of persistence in normal times. Participants would seek to fulfil these persistent liquidity needs by rolling over overnight repo contracts. The posterior probability of inclusion of lagged repo volume in the same collateral type of 100%, along with a "posterior T-statistic" of over 3 is consistent with the prevalence of such a rollover strategy in Canada.

It is interesting that uncollateralised lending volume is not strongly persistent. Since uncollateralised lending is usually more expensive than repos and therefore is usually the last resort to acquiring liquidity, this lack of strong autocorrelation suggests that market participants use these loans to meet unanticipated lending needs. Further bolstering this argument is the weakly positive effect of financial sector volatility on the volume of uncollateralised loans. The pip of both the crude oil price volatility and financial stress variables is about 65%, and the mean effect is positive, even if the posterior mean has a large posterior standard deviation. In sum, this evidence points to the use of uncollateralised loans (repos) to meet the unexpected (persistent) liquidity needs of the financial system.

Turning to the effect of substitutes, the general effect we see is of a decrease (increase) in volume when the price of a substitute falls (rises). The precise substitute sources, however, vary by collateral type. GoC repo volume falls with an increase in the spread between the central bank lending rate and the 90-day deposit rate. Short-term deposits are arguably the closest substitute to borrowing against the safest collateral; it is not surprising that a decrease in the deposit rate (which widens the spread discussed above) has a strong negative effect on GoC repo volume. A similarly strong, but positive, effect is due to an increase in the rate of repos backed by Provincial bonds – as can be expected when a substitute funding source becomes cheaper. While both these substitute rates have a strong probability of inclusion, the mean magnitude of their effect is rather small, since the high posterior density intervals include zero.[16]

A close substitute to repos using Provincial government securities is the issuance of Bankers' Acceptances. A rise in the spread between Bankers' Acceptances with three months and one month to maturity suggests a cheapening of this alternate funding source, which weakly reduces the volume of Provincial repos. The credible sets, however, include zero, which implies that one cannot exclude that this effect is trivial.[17]

The third salient fact to emerge from the analysis of the determinants of repo volumes is that all collateralised volumes fall with an increase in the margin of the one-year adjustable

[16] Intriguingly, the volume of CMB repos falls when the price of its closest substitute increases. An increase in the cost of borrowing using the riskiest collateral (of the three types considered) prompts a shift towards using the safest collateral, and a fall in the use of collateral of intermediate credit risk.

[17] Also puzzling is the positive increase in uncollateralised lending when Bankers' Acceptances with one month to maturity become cheaper.

rate mortgage. This decline is strong for the safest collateral types (GoCs and CMBs), and also has a large magnitude for CMB repos. This variable has a positive effect for Provincial repos, and none for uncollateralised loan volumes. To interpret this result, we turn to the literature on the determinants of the margin of adjustable mortgages (spread over the Treasury bill rate). Sprecher and Willman (1998) argue that the margin (at the aggregate level) is determined by the liquidity needs of the financial sector, while Furlong et al. (2014) make a related case for the importance of the effect of general credit supply conditions. Elliehausen and Hwang (2010) present a model in which financial institutions use the margin to protect themselves against the risk of prepayment. Margins are therefore higher in times of higher interest-rate uncertainty. Higher interest-rate uncertainty has two countervailing effects. First, it increases the incentives to hedge exposure to this risk, which increases the liquidity needs of the financial system. Second, as Bretscher et al. (2016) show, it strongly reduces investment in the broader economy, and consequently the demand for liquidity in the financial system by reducing the credit demanded from that sector. The result that an increase in the margin reduces the repo volume for all collateral types suggests that the latter effect dominates. In effect, repo volume falls with the liquidity demands of the financial sector.

5.2 Determinants of lending rates

The third column in Table 2 contains the posterior statistics for the spread of the different loan types over the overnight target rate. The results show that (i) the Bank of Canada is effective in maintaining its target rate, (ii) the loan rates against the riskier collateral include a credit spread, and (iii) borrowing against riskier collateral becomes more expensive in times of financial uncertainty and liquidity stress.

The rate for overnight repos collateralised by the safer classes of collateral (GoC and CMB securities) is distributed randomly around the overnight target rate, even as their volumes are persistent. Given that the Bank of Canada actively manages the repo rate against GoC collateral, it is not surprising that there is no systematic factor we could find that affects the spread of GoC-collateralised repos over the target rate. CMBs are close substitutes to GoCs in terms of their credit risk, which could explain the unpredictability of the repo spread over target when they are used as collateral.

The rate spread of loans against the riskier collateral (Provincial government bonds, or in the case of uncollateralised loans, the reputation of the borrower), on the other hand, is strongly autocorrelated and statistically significant. This persistent component could be the spread charged by lenders to protect themselves against the higher credit risk of the collateral. This interpretation is bolstered by the fact that the persistence of these spreads is net of any effects due to change in the volume of such loans.

The third salient feature of the results is the increase in the rate spreads for loans against the riskier collateral with economic uncertainty and financial stress. A rise in the CDOR-OIS spread – an indicator of funding pressures experienced by the financial system; see the discussion in Sengupta and Yu (2008) for the U.S. counterpart of this measure – is positively related with a rise in the repo spread backed by Provincial government securities. Similarly, a rise in the U.S. VIX is weakly associated with increased uncollateralised lending spread. These results indicate that lenders charge an extra spread during worse financial conditions to compensate for the increased risk of the underlying collateral being offered.

Finally, the spreads on loans backed by Provincial bonds and uncollateralised loans react to the behaviour of substitute markets. Spreads for Provincial repos fall weakly with a rise in the volume of CMB repos, and those for uncollateralised loans rise with the retail loan rate spread, an indicator of the cost of providing liquidity to retail clients.[18]

5.3 Determinants of haircuts

Haircuts are applied to the collateral provided by the borrower to protect the lender against adverse movements in the market price of the collateral upon borrower default. Thus, haircuts are influenced both by the credit risk of the borrower, and the market price volatility of the security (which depends on, among other factors, the credit risk of the issuer). See Gorton and Metrick (2010), Comotto (2012), Hu et al. (2015) and Lou (2016) for an in-depth discussion of repo haircuts.

The determinants of repo haircuts for the different collateral types in Canada are presented in the fourth set of columns in Table 2. Two broad conclusions can be drawn. First, haircuts applied to CMB and Provincial bonds have a persistent component that reflect their higher credit risk. Second, lenders seek to incentivise borrowers to switch to safer collateral by decreasing haircuts for safer collateral in times of financial stress.

There is no autocorrelation in the haircuts applied to GoC securities. This is because about 85% of repos involving GoC securities have 0% haircuts; the rest have haircuts of

[18]Surprisingly, however, the spread of Aaa corporate bond yields over the Federal funds rate positively affects the Provincial repo spread, but in the opposite direction. A rise in the yield spread of Aaa bonds decreases the cost of funding through Provincial repos. The magnitude of this effect is large, and statistically significant.

about 2% (Bulusu and Gungor (2017)). However, the haircuts on CMB and Provincial bonds are decisively autocorrelated, perhaps reflecting the consistently positive haircuts applied owing to their higher credit risk.

CMB repo haircuts fall with an increase in financial stress. As described earlier, financial market participants turn to the uncollateralised market to fulfil their liquidity needs in such conditions. The decrease in haircuts for CMB collateral may be read as an incentive provided by lenders to borrowers to switch them to providing collateral. This mechanism may not apply to GoC collateral, since the majority of such repos already have 0% haircuts. On the other hand, lenders may find Provincial government securities less desirable during such stressed periods, and consequently do not reduce the haircut applied to such collateral.

The haircut applied to all collateral classes responds to substitute source of liquidity. When alternate funding sources become cheaper, lenders decrease haircuts to make it more attractive to post collateral. For example, a fall in the 3-month to 1-month spread of Bankers' Acceptances (spread of the Bank rate to the 5-year fixed deposit rate) has a strong (positive) effect on the decline in the haircuts applied to GoC collateral. This effect is also has a large magnitude, compared to the posterior standard deviation of the estimates. A decrease in the 90-day deposit rate decisively increases the Provincial haircut – perhaps because lenders are wary of borrowers posting lower-quality collateral instead of accessing alternate, cheaper, funding sources (deposits, in this case). An increase in the haircut charged on Provincial collateral is accompanied by a strong reduction in the haircut applied to CMBs, which have lower credit risk.

6 A dynamic analysis of interbank lending

The BMA analysis is helpful to obtain evidence on the possible factors affecting repo market activity. In this section, we examine the dynamic effects of these different factors.

One drawback of the analysis in the previous section is that we only obtain static effects of a given predictor on the dependent variable of interest. In contrast, vector autoregressive (VAR) models permit us to model the dynamic interactions in the data. We use bivariate structural VARs to provide a quantitative assessment of the channels of transmission of the different drivers of the repo market. In doing so, we calculate structural impulse responses to quantify the causal relationships in the data. We postulate that the key drivers of the repo market we uncovered in the previous section (i.e., the margin on 1-year adjustable-rate mortgages, the financial stress index, and the U.S. VIX) are predetermined with respect to the interbank lending variable (volume, rate and haircut for all repos, and volume and rate of uncollateralised lending). This assumption means that unpredictable changes in one of the key aforementioned drivers affect the interbank lending variable of interest within a given week, but are not themselves subject to instantaneous feedback from the interbank lending variable. This is intuitive given that the drivers of the repo market variable are U.S. variables that are not expected to reflect changes in Canadian repo market variables simultaneously.

We focus on the dynamic response of interbank loans to these three variables for two reasons. First, we choose not to include the price of substitute sources of liquidity in our analyses. The identification of the VAR would be complicated by the fact that the prices and volumes of interbank loans and their substitutes are jointly determined. Second, we also limit ourselves to bivariate VARs, motivated by the fact that structural VAR based on larger systems of variables would necessitate longer sample sizes than the data we use (weekly data from September 2009 to December 2015). Given this setting, we limit our analysis to the dynamic response of the terms of interbank lending to shocks to variables that are plausibly exogenous, and have been identified as key determinants from the preceding BMA analysis.

In detail, we consider the following bivariate VAR model, which is written in reduced-form as follows

$$Z_t = A_0 + \sum_{i=1}^{p} A_i Z_{t-1} + e_t,$$

where e_t is a Gaussian white noise process with mean zero and covariance matrix Σ. The vector Z_t includes one of the four drivers mentioned above and one interbank loan variable. Let e_t denote the reduced-form VAR innovations such that $e_t = B_t^{-1} u_t$. The structural innovations u_t are derived by imposing exclusion restrictions on the B_t^{-1} matrix, assuming a recursive identification scheme. For all collateral types, the loan volume is taken in log-level. All other variables (rates and haircuts) are in level. Such specifications are chosen to ensure consistency of the estimates regardless of the possible cointegration between the variables (see, e.g., Sims et al. (1990)).[19] All shocks are scaled as a one standard deviation increase in the first variable of the system. This corresponds to a 60 basis point increase in the margin on 1-year adjustable mortgage rate, a 0.45 unit increase in the financial stress index and a 5.85 unit increase in the VIX. Scaling the shocks in terms of an increase in

[19]Gospodinov et al. (2013) also show that impulse response analysis conducted with the VAR levels specification tends to be more robust compared with the pretest approach for VAR models. This is especially acute in small sample sizes when the magnitude of the unit roots and the co-movement between the variables is not known.

observable variables allows us to perform a fair comparison of the effect of a given shock on the different terms of trade of interbank lending (volume, rate and haircut). Moreover, as the VAR models we estimate are linear, the scaling of the shocks is innocuous.

A few additional comments are required. As in section 3, the sample size extends from the first week of September 2009 to the last week of December 2015. All VAR models are estimated with the least squares method. The lag length of the VAR system is set according to the Akaike Information Criterion (AIC) using a maximum lag of 52. Impulse responses are plotted up to a 25-week horizon, and 90 percent bootstrapped confidence bands display the precision of the estimates.

The results of the bivariate VAR analysis are organised as follows. Figures 2, 3, 4 and 5 plot the impulse-response functions for uncollateralised loans, GoC repos, CMB repos and Provincial repos, respectively. Each row of figures plots the response of the dependent variable to shocks to the variable indicated in the title. For example, the first row of each figure contains the results for a one-standard-deviation surprise increase in the U.S. VIX. The dependent variable is one of the three terms of trade – (log) volume, rate spread, and haircut – in each column of figures.

This dynamic analysis helps us understand that the effects highlighted by the cross-sectional analysis are quite persistent. First, increased financial sector volatility and stress turns market participants to search for liquidity in the uncollateralised market, even at the cost of higher rates. This effect lasts at least up to twenty-five weeks after the initial shock, even as the magnitude of the effect declines over time. As discussed earlier, the uncollateralised market is mostly where unanticipated liquidity needs are satisfied. The persistent impact of financial stress therefore suggests that market participants are unable to immediately adjust either their expectations of liquidity needs, or their ability to finance themselves in the collateralised market. In fact, we see that repos collateralised by CMBs and Provincial bonds show a persistent drop despite their haircuts being lowered in response to a financial stress shock. This suggests that such stresses increase the alternate uses of such collateral. Second, lower liquidity needs in the system lead to a persistent decline in the volume of CMB and Provincial repos. The drop in volume is higher for Provincial repos than for CMB repos, and is observed despite lenders significantly lowering the haircuts applied on these collateral types long after the shock that decreases systemic liquidity needs. We now discuss these results in greater detail.

Figure 1 shows that financial volatility has a long-lasting impact on both the volume and the cost of uncollateralised borrowing. A one-standard-deviation surprise increase in the U.S. VIX increases overnight uncollateralised loan volume by about 7% on impact. This increase declines monotonically over time to 1% twenty-five weeks later. The (annualised) cost of uncollateralised lending rises by about 30 basis points in the week following the rise in U.S. VIX. A one-standard-deviation surprise rise in the financial stress index increases significantly volume with a peak impact at a 3-week horizon, and elevates the borrowing costs by about 50 basis points from five weeks to twenty-five weeks later. The systemic liquidity need shock leads to a temporary decline in volume with a maximum effect at a 1-week horizon and the rate does not react significantly to such a shock in line with the results from the cross-sectional analysis.

In contrast to the strong and persistent impact on the uncollateralised loan volume, the uncertainty shock has only a temporary impact on GoC repo volumes. GoC repo volume rises by about 8% two weeks after an unexpected one-standard-deviation increase in the U.S. VIX, and becomes statistically indistinguishable from zero beginning nine weeks later. A surprise increase in the financial stress index increases GoC repo volume by 14% on impact, but the effect of the shock quickly dies out. These higher volumes are accompanied by a rise in repo rates of 22 basis points a week later, in response to the uncertainty shock, and between 30 basis points and 40 basis points for the first three weeks after a surprise increase in the financial stress index. These responses are consistent with satisfying greater liquidity needs of the financial system following such shocks.

The BMA results suggested that financial stresses do not affect the haircuts applied to GoC collateral in the cross-section. The VAR analysis shows that a surprise increase in financial stress has a delayed, but long-lasting, effect in reducing the haircut. Haircuts on GoC collateral fall significantly by about 2% beginning week nine after a shock to the financial stress index, and decrease further to 4% up to twenty-five weeks. Thus, lenders incentivise borrowers to provide safer collateral, which is more desirable in stressed financial conditions. This effect is large, given that most GoC repos have 0% haircuts to begin with.[20]

While elevated financial uncertainty and stress drive uncollateralised lending and GoC repo volumes up (the latter experiencing only a temporary increase), it has the opposite effect on the volume of CMB and Provincial repos. Surprise increases in the U.S. VIX lead to a peak adverse impact on CMB repo volume at a 18-week horizon (about a 6% fall), and the financial stress shock leads to a 15% fall at a 24-week horizon. This persistent decrease in volume is not accompanied by significant changes to the repo rate, and even a significant decline in the haircuts applied (to the tune of between 3% and 8%) lasting from two to twenty-five weeks after the shock.

[20]The responses to a one-standard-deviation increase basis in the adjustable-rate mortgage margin is larger – about a 9% fall after three weeks. These lower haircuts are not accompanied by significant changes in the GoC repo volume or rates. This result is hard to interpret.

This pattern of persistent decline in volumes accompanied by a decrease in haircuts is also observed for Provincial repos, with the effect being even larger than that for CMB repos. The same shocks to the U.S. VIX and financial stress index result in a maximum decline of about 10% and 42% respectively. Haircuts on Provincial repos decline by 16% (9%) on impact (at a one-week horizon), but moderate their fall to -5% (-1%) by the twenty-fifth week after the shock to the financial stress index (U.S. VIX). The fact that borrowers are willing to pay a higher price for uncollateralised loans despite lenders making using CMB and Provincial bonds more attractive suggests alternate uses for these bonds after an increase in financial stress/uncertainty.

Consistent with the results of the cross-sectional analysis, a shock to liquidity demanded by the financial sector persistently lowers CMB repo and Provincial repo volumes by 13% and 48%, respectively. This effect is not accompanied by significant changes in the repo rate, even if the haircut on Provincial bonds falls by about 10% eight weeks after the shock materialises (haircuts for CMBs are not significantly affected). As discussed earlier, the fall in haircut could be interpreted as an inducement offered by lenders to increase borrowing. The persistent fall in volumes is consistent with declining economic activity – and consequently reducing liquidity needs – due to higher expected interest rate volatility.

7 Conclusion

This paper investigates the drivers of interbank loans in Canada using a unique dataset of uncollateralised and collateralised (repo) loans, and exploiting the Bayesian model averaging technique to evaluate the effect of a large number of potential determinants. We find that the prices of substitute liquidity sources, financial stress, and systemic liquidity needs play an important role in determining the total loan volume and rate, and the haircut applied on collateralised loans. These effects are both heterogeneous across the different collateral types. Further, a structural VAR analysis also shows that these effects are long-lasting in response to a shock to financial stress and systemic liquidity needs, especially for loans against the less credit-worthy collateral.

The evidence uncovered in this paper suggests that collateralised lending is largely used to cover anticipated liquidity needs, while uncollateralised loans are primarily used to satisfy unexpected needs for cash. Thus, when the liquidity needs of the financial system decline, it is the volume of collateralised lending that falls, especially using riskier collateral.

The cost of borrowing against the safest collateral fluctuates randomly around the overnight target rate, suggesting the effective implementation of monetary policy in Canada.

The rates charged by lenders against riskier collateral is persistent, consistent with the presence of a credit spread. Further, borrowing against the more riskier collateral becomes more expensive when financial and liquidity stresses rise.

The haircuts applied on the riskier collateral have a persistent component, reflecting an additional source of creditor protection. We also find evidence that haircuts are lowered in response to financial stress, suggesting that haircuts are used by lenders to incentivise posting collateral. Lenders may therefore prefer to lend against collateral than to take the higher risk and earn higher returns from offering uncollateralised loans.

The importance of interbank markets in maintaining a well-functioning financial system has been spurred efforts to collect data on these markets (see, e.g., Adrian and Shin (2008)). While existing studies of interbank lending have focused on individual sub-markets, our study provides guidance to studies seeking to understand the factors driving interbank lending, while recognising the inter-linkages between these segments.

Given the increasing use of central counterparties post the great financial crisis as a means to reducing systemic risk (see the discussion in Duffie and Zhu (2011) and Boissel et al. (2017)), the reaction of market participants to their introduction deserves attention (see Koeppl (2013) for a theoretical treatment). Due to the lack of a sufficiently long time series, we also leave the exploration of the impact of the introduction of a central counterparty on the behaviour of the different segments of the interbank loan market to future work.

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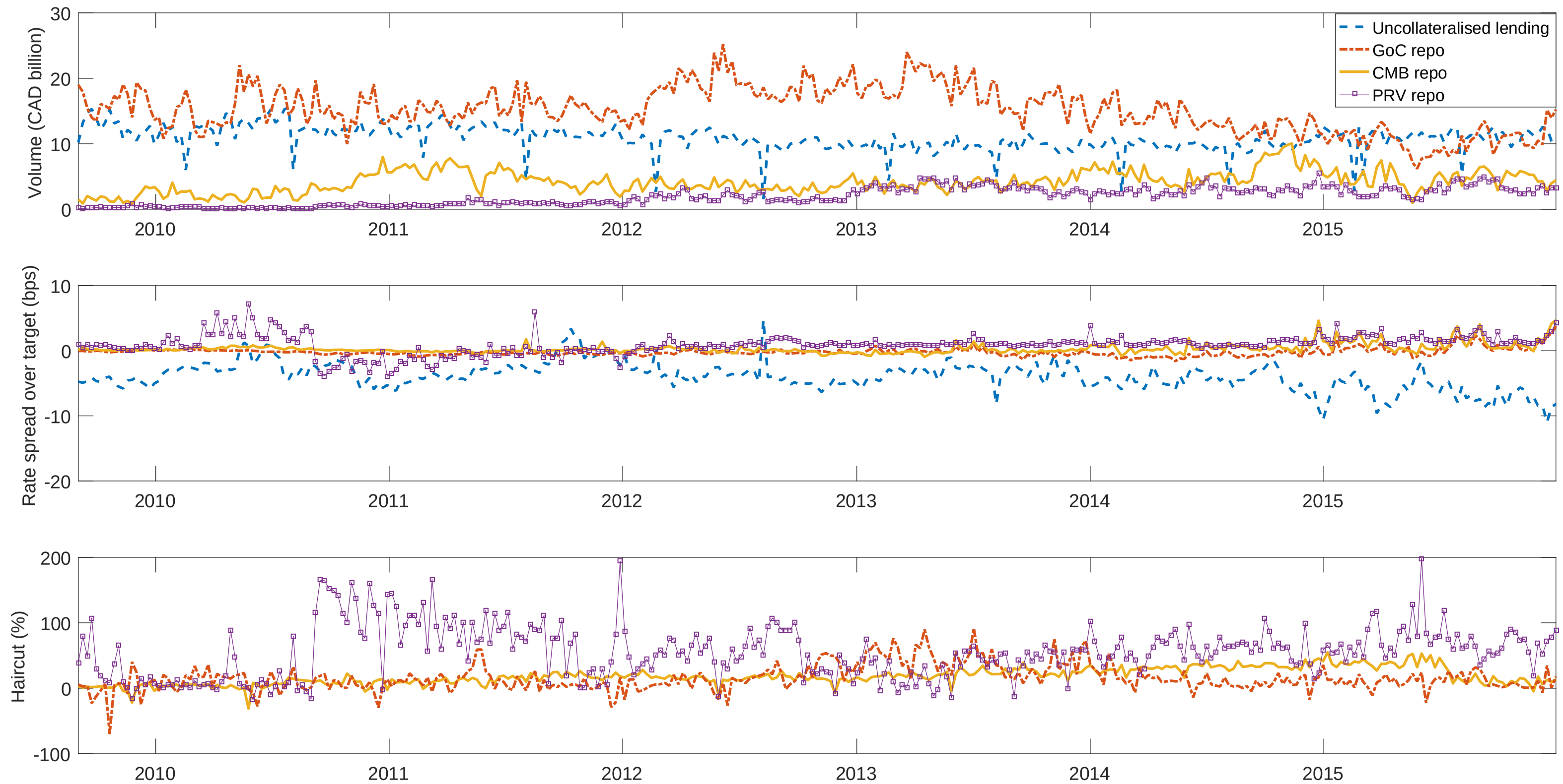
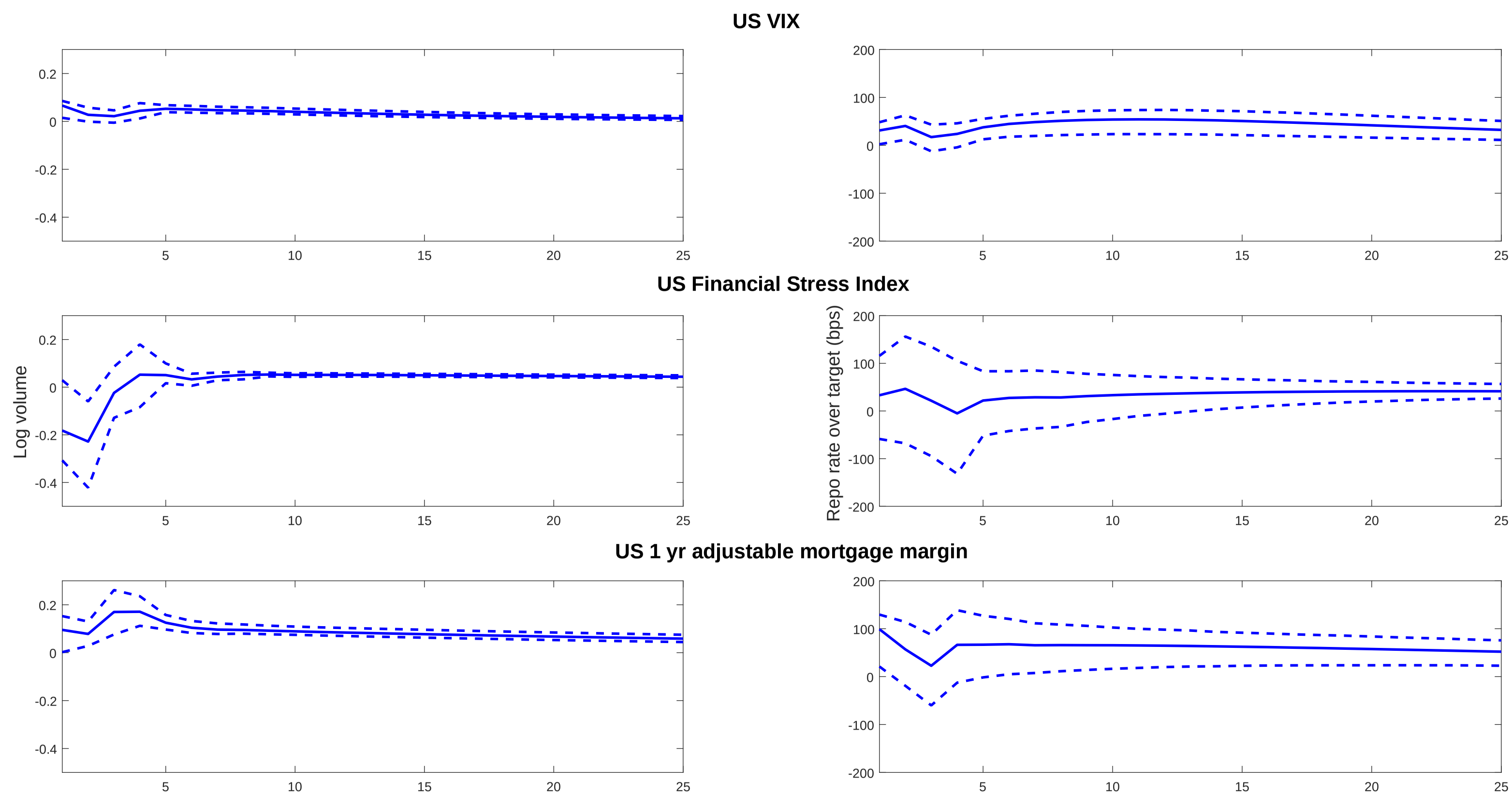
Figure 1: Interbank lending – terms of trade



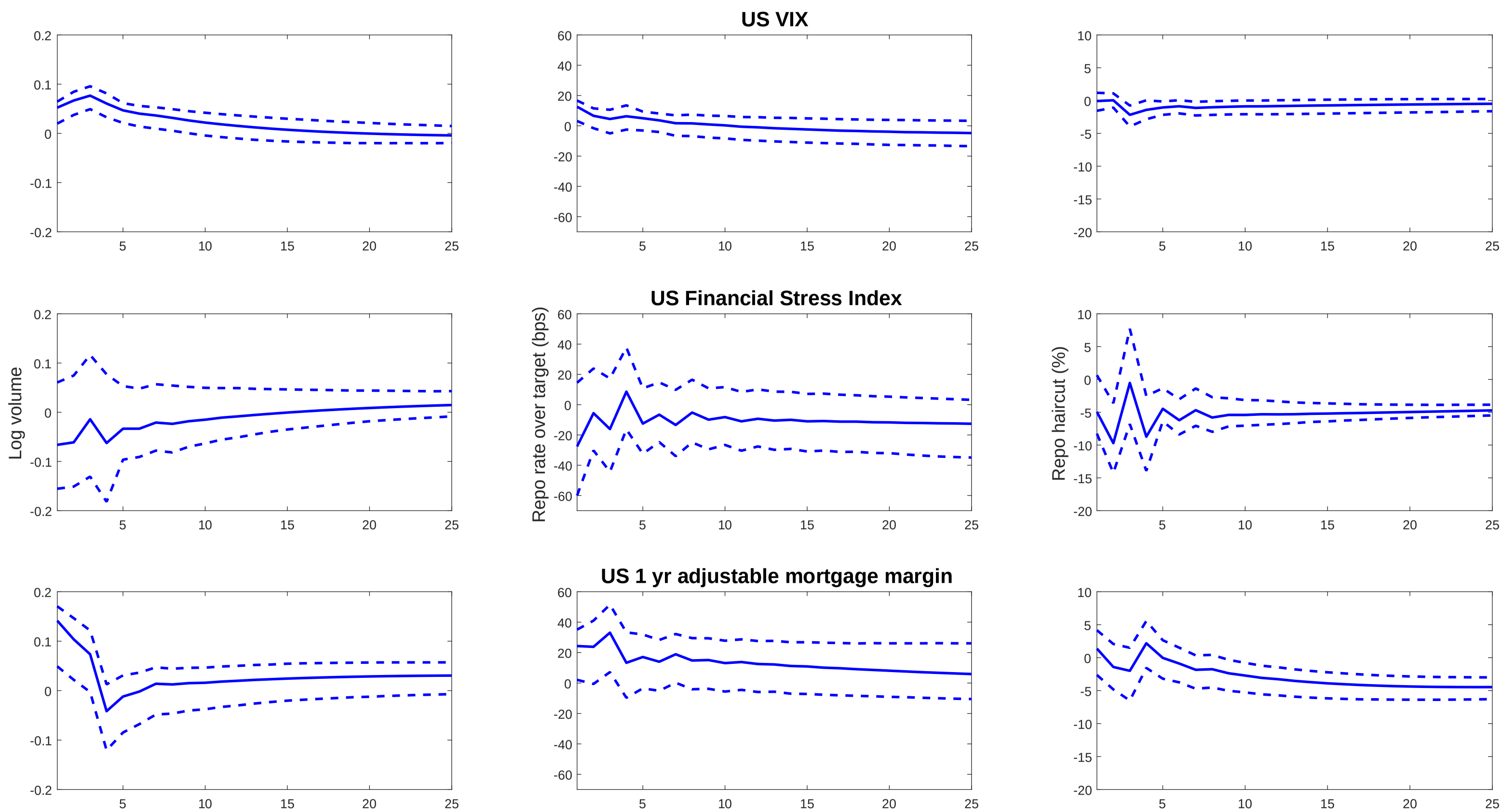
Note: Time series of the average daily volume, loan rate spread over the Bank of Canada overnight target rate, and the haircut of each type of interbank loan in week used in study.

Figure 2: Impulse responses of the terms of uncollateralised lending to uncertainty, financial stress, and systemic liquidity need shocks



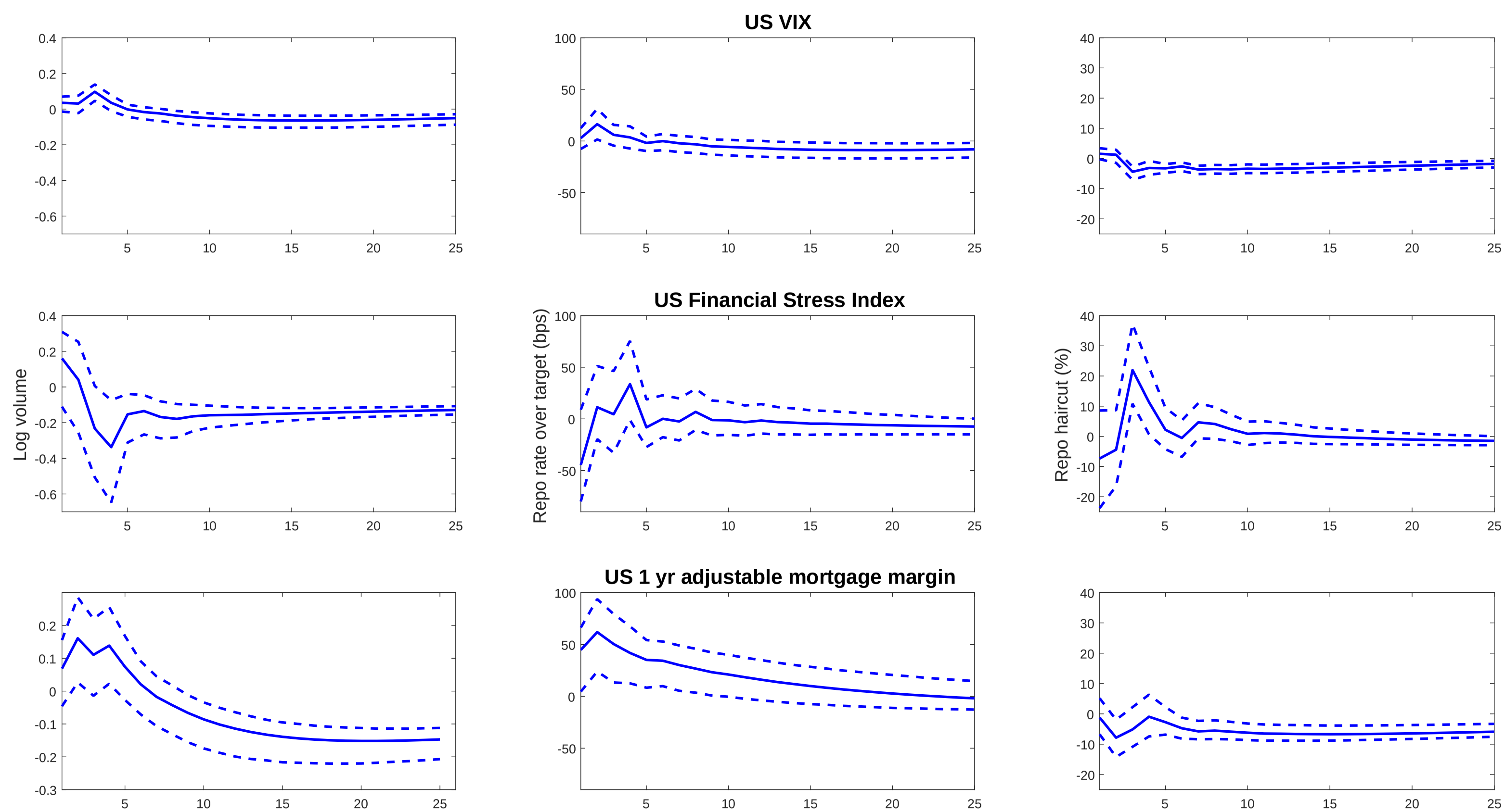
Note: Structural impulse responses from weekly bivariate vector autoregressions with 90 percent bootstrapped confidence bands. The uncertainty shock is scaled to match a 10-point increase in the VIX, the liquidity need shock is scaled to correspond to a 10 basis point increase in the spread between the 1-year adjusted mortgage rate and the Federal Funds rate and the financial stress shock matches a one standard deviation increase in the financial conditions index. The identifying assumption is that the VIX, the financial stress index, and the margin on 1-year adjustable-rate mortgages are all predetermined with respect to the log lending volume, and the spread of the lending rate over target.

Figure 3: Impulse responses of the terms of repos backed by Government of Canada bonds to uncertainty, financial stress, and systemic liquidity need shocks



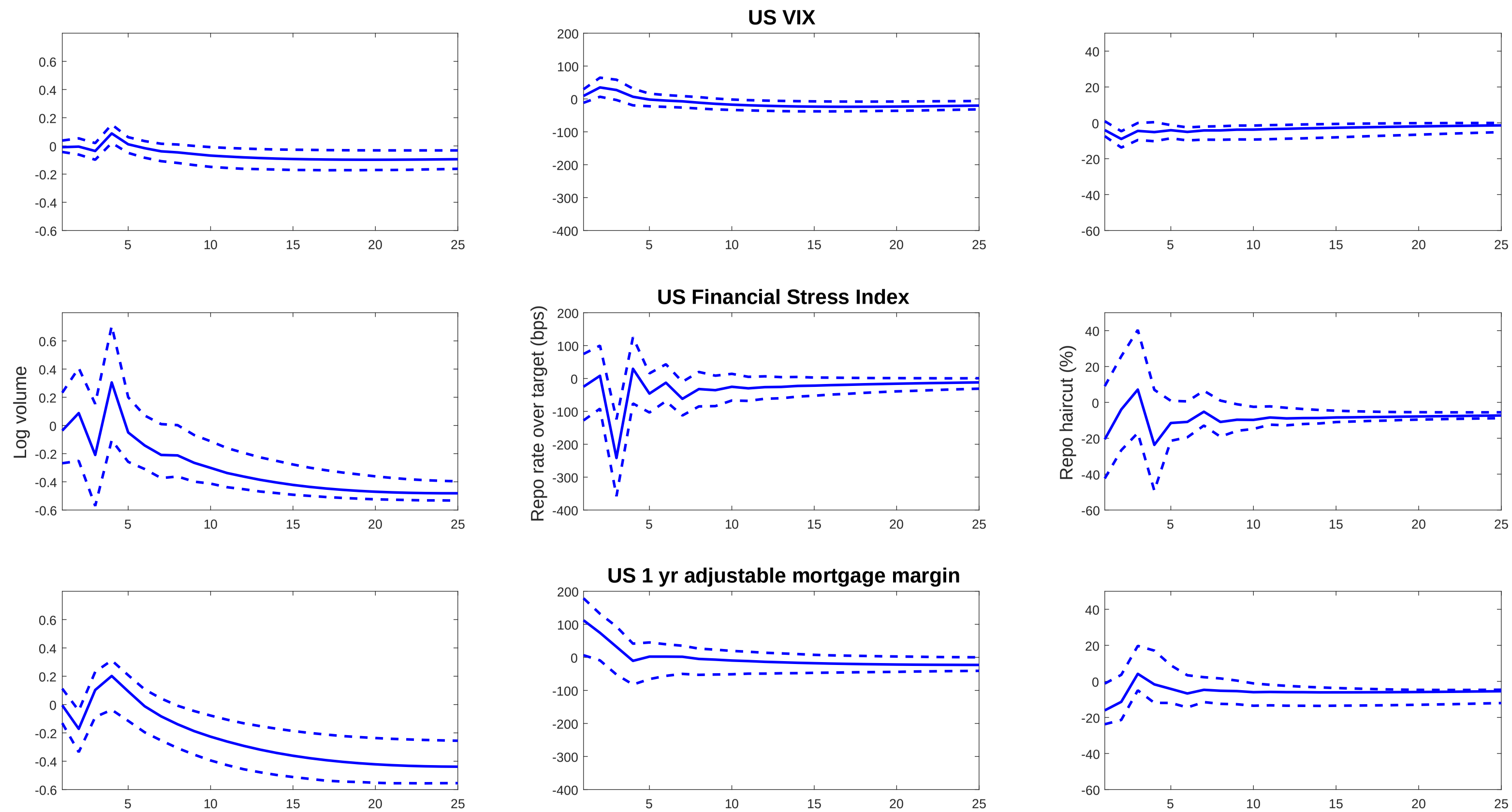
Note: Structural impulse responses from weekly bivariate vector autoregressions with 90 percent bootstrapped confidence bands. The uncertainty shock is scaled to match a one-standard-deviation increase in the VIX, the spread between the 1-year adjusted mortgage rate and the Federal Funds rate, and the financial stress index. The identifying assumption is that the VIX, the financial stress index, and the margin on 1-year adjustable-rate mortgages are all predetermined with respect to the log lending volume, the spread of the repo rate over target, and the haircut.

Figure 4: Impulse responses of the terms of repos backed by CMBs to uncertainty, financial stress, and systemic liquidity need shocks



Note: Structural impulse responses from weekly bivariate vector autoregressions with 90 percent bootstrapped confidence bands. The uncertainty shock is scaled to match a one-standard-deviation increase in the VIX, the spread between the 1-year adjusted mortgage rate and the Federal Funds rate, and the financial stress index. The identifying assumption is that the VIX, the financial stress index, and the margin on 1-year adjustable-rate mortgages are all predetermined with respect to the log lending volume, the spread of the repo rate over target, and the haircut.

Figure 5: Impulse responses of the terms of repos backed by Provincial bonds to uncertainty, financial stress, and systemic liquidity need shocks



Note: Structural impulse responses from weekly bivariate vector autoregressions with 90 percent bootstrapped confidence bands. The uncertainty shock is scaled to match a one-standard-deviation increase in the VIX, the spread between the 1-year adjusted mortgage rate and the Federal Funds rate, and the financial stress index. The identifying assumption is that the VIX, the financial stress index, and the margin on 1-year adjustable-rate mortgages are all predetermined with respect to the log lending volume, the spread of the repo rate over target, and the haircut.

Table 1: Variable definitions.

Variable	Description and sources
	Substitute market prices
Retail loan - ON tgt rate	Spread between the rate at which Canadian Chartered Banks offer retail loans and the Bank of Canada's overnight target. Sources: Consumer loan rates are from Table 176-0078 from Statistics Canada. Daily overnight target rate in Canada is from the Bank of Canada's website.
3m-1m Commerical Paper rate	Weekly average spread between Commerical Paper with three months and one month to maturity in Canada. Source: BFS Table F1 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
3m-1m Bankers' Acceptances rate	Weekly average spread between Bankers' Acceptances with three months and one month to maturity in Canada. Source: One-month and three-month Bankers' Acceptances yields are from Table 176-0078 from Statistics Canada.
3m-1m fwd premium	The spread between the three-month and one-month forward premium of United States dollars in Canada. Source: The one-month and three-month forward premium is from Table 176-0078 from Statistics Canada.
Bank - 90d deposit rate	Spread between the Bank of Canada overnight target rate and the rate offered by Chartered Banks in Canada for 90-day term deposits. Source: The Canadian overnight target rate is from the Bank of Canada's website. The 90-day term deposit rate is from Table 176-0078 from Statistics Canada.
Bank - 5y fixed deposit rate	Spread between the Bank of Canada overnight target rate and the rate offered by Chartered Banks in Canada for five-year personal fixed term deposits. Source: The Canadian overnight target rate is from the Bank of Canada's website. The five-year fixed deposit rate is from Table 176-0078 from Statistics Canada.
3m AA fin bond - Fed funds rate	Average daily spread between the three-month yield on bonds issued by AA-rated financial firms and the Federal funds rate in week. Sources: Yield on AA-rated financial firms from Board of Governors of the Federal Reserve System (US), 3-Month AA Financial Commercial Paper Rate, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WCPF3M. The Federal funds rate is at the website of the Federal Reserve Bank of New York, https://apps.newyorkfed.org/markets/autorates/fed%20funds.
Aaa corp bond - Fed funds rate	Average daily spread between Moody's seasoned Aaa corporate bond yield and the Federal funds rate in week. Source: Federal Reserve Bank of St. Louis, Moody's Seasoned Aaa Corporate Bond Minus Federal Funds Rate, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/AAAFFM
	Term premia
10y-2y yield spread	Weekly average spread between yields on Government of Canada bonds with ten years and two years to maturity. Source: The yields on ten-year and two-year Candian government bonds are available in Table 176-0078 from Statistics Canada.
1y-1m yield spread	Weekly average spread between yields on Government of Canada bills with one year and one month to maturity. Source: The yields on one-year and one-month Candian government bills are available in Table 176-0078 from Statistics Canada.
10y-6m yield spread	Weekly average spread between yields on Government of Canada bonds with ten years and Government of Canada bills with six months to maturity. Source: The yields on ten-year and one-month Candian government bonds/bills are available in Table 176-0078 from Statistics Canada.
5y-1y mortgage rate	The spread between the rate on conventional mortgages offered by commercial banks with five years and one year to maturity. Sources: The five-year and one-year mortgage rates are available from Table 176-0078 from Statistics Canada.
3m EUR-USD spread	Average annualised daily yield on three-month Eurodollar deposits in week. Source: Board of Governors of the Federal Reserve System (US), 3-Month Eurodollar Deposit Rate (London), retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WED3, February 27, 2017.
	Economic and financial uncertainty indicators

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Table 1 – *Continued from previous page*

Econ Policy Uncertainty Index	The weekly average of the Baker et al. (2016) measure of economic policy uncertainty in the United States. Source: Baker, Scott R., Bloom, Nick and Davis, Stephen J., Economic Policy Uncertainty Index for United States, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/USEPUINDXD.
CBOE Crude Oil Volatility Index	The daily average of the expectation of 30-day crude oil price volatility in week. Source: The website of the CBOE, http://www.cboe.com/products/vix-index-volatility/volatility-on-etfs/cboe-crude-oil-etf-volatility-index-ovx.
1y adj mortgage margin	Daily average of the spread between the rate on 1-year adjustable rate mortgages in the United States and the Fed funds rate in week. Sources: Freddie Mac, 1-Year Adjustable Rate Mortgage Average in the United States, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/MORTGAGE1US. The Fed funds rate is at the website of the Federal Reserve Bank of New York, https://apps.newyorkfed.org/markets/autorates/fed%20funds.
U.S. VIX	Average of the index of 30-day implied volatility of the S&P 500 index in week. Source: Available from the website of the CBOE, http://www.cboe.com/products/vix-index-volatility/vix-options-and-futures/vix-index.
Canadian VIX	Average of the index of 30-day implied volatility of the Canadian S&P/TMX 60 index in week. Source: Available at the website of the TMX Montreal Exchange from 1 October 2009. Back-filled for the month of September 2009 using the daily percentage change in the previous volatility index (MVX) provided on the website of the TMX Montreal Exchange, https://www.m-x.ca/indicesmx_vixc_en.php.
3m fwd spread	Closing value of the 3 month USD-CAD forward spread in week. Source: BFS Table F1 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
1y swap spread	The spread between the rate payed on a one-year swap by a fixed-rate payer in exchange for the three-month LIBOR, and the Federal Funds rate. Sources: Board of Governors of the Federal Reserve System (US), 1-Year Swap Rate, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WSWP1. The Fed funds rate is at the website of the Federal Reserve Bank of New York, https://apps.newyorkfed.org/markets/autorates/fed%20funds.
Financial stress indicators	
CDOR-OIS spread	The spread between the Canadian Dollar Offer Rate (CDOR) and the Overnight Indexed Swap rate.
CERI	Canadian dollar effective exchange rate index, the Bank of Canada's new measure of the value of the Canadian dollar against the currencies of its most important trading partners. See Barnett et al. (2016) for details. Source: Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
Financial stress index	Daily average of St. Louis Fed Financial Stress Index in week. Source: Federal Reserve Bank of St. Louis, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/STLFSI, February 27, 2017.
High-frequency macroeconomic indicators	
4w initial unempl claims	4-Week moving average of initial claims from the Unemployment Insurance Weekly Claims Report. Source: U.S. Employment and Training Administration, retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/IC4WSA
WTI spot price	Average West Texas Intermeidate spot price in week. Source: U.S. Energy Information Administration, Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma., retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/WCOILWTICO
ADS index	Daily average of the Aruoba-Diebold-Scotti Business Conditions Index in the United States in the week. Source: The website of the Federal Reserve Bank of Philadelphia, available at https://www.philadelphiafed.org/research-and-data/real-time-center/business-conditions-index.
Bank of Canada / Government of Canada liquidity indicators	
Notes in circulation	Volume of CAD notes in cicrulation in week. Source: BFS Table B2 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.

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GoC deposits at BoC	Daily average Government of Canada cash deposits with the Bank of Canada in week. Source: BFS Table B2 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
PC member deposits	Daily average deposits by members of Payments Canada (formerly Canadian Payments Association) with the Bank of Canada in week. Source: BFS Table B3 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
Overdraft loans at BoC	Daily average overdraft loans provided by the Bank of Canada to members of Payments Canada (formerly Canadian Payments Association) in week. Source: BFS Table B3 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
Positive balances at BoC	Daily average volume of positive balance on books of the Bank of Canada by members of Payments Canada (formerly Canadian Payments Association) in week. Source: BFS Table B3 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
BoC term repo volume	Volume of term repo operations conducted by the Bank of Canada in week. Source: BFS Table B3 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
GoC T-bill auction volume	Net amount of T-bills auctioned by BoC in week. Source: BFS Table B2 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/.
BoC OMO volume	Net amount of open market operations conducted by the Bank of Canada in week. Source: BFS Table B3 of the Bank of Canada weekly financial statistics bulletin, archived at http://epe.lac-bac.gc.ca/100/201/301/weekly_fin_stats/ .

Note: This table contains the description – and sources – of all the determinant variables used in this paper. Twelve other independent variables are used in the analysis: nine repo market variables - the log volume, rate spread over the Bank of Canada overnight target, and haircut for repos collateralised by each of GoC, CMB and provincial government securiites; two uncollateralised loan variables - the log volume and rate spread over the Bank of Canada overnight target; and the weighted average loan rate.

Table 2: Determinants of the terms of interbank lending.

	Volume (log)			Avg spread over ON tgt			Avg haircut		
	PIP	μ_{post}	T_{post}	PIP	μ_{post}	T_{post}	PIP	μ_{post}	T_{post}
Panel A: Uncollateralised overnight lending									
Uncollateralised loan - ON tgt rate	0.08	-0.0815	-0.13	**1.00**	**0.7477**	**17.00**			
Interbank funding rate	**0.62**	**-3.1365**	**-0.70**	0.02	0.0002	0.01			
Retail loan - On tgt rate	0.13	-0.0048	-0.21	**0.78**	**0.0035**	**1.63**			
3m-1m Bankers' Acceptances rate	**0.75**	**1.2754**	**0.84**	0.04	0.0014	0.15			
CBOE crude oil vol index	**0.63**	**0.0027**	**0.78**	0.08	0.0000	-0.19			
Financial stress index	**0.65**	**0.1025**	**0.94**	0.05	0.0001	0.14			
US VIX	0.03	-0.0001	-0.04	**0.52**	**0.0002**	**0.92**			
Panel B: Overnight repo against Government of Canada collateral									
GoC-collateralised repo volume	**1.00**	**0.6115**	**3.65**	0.03	0.0058	0.09	0.03	0.0036	0.10
Prov-collateralised repo - ON tgt rate	**0.97**	**2.6431**	**1.05**	0.09	-1.0013	-0.28	0.09	-0.4116	-0.28
3m-1m Bankers' Acceptances rate	0.02	-0.0002	0.00	0.02	-0.0570	-0.08	**0.98**	**-7.0822**	**-3.59**
Bank - 90d deposit rate	**0.91**	**-0.2735**	**-0.90**	0.02	0.0032	0.03	0.22	0.1253	0.47
Bank - 5y fix deposit rate	0.03	-0.0123	-0.03	0.02	0.0021	0.00	**0.88**	**-9.3316**	**-2.09**
1y adj mortgage - Fed funds rate	**0.98**	**-0.2157**	**-1.45**	0.04	0.0059	0.14	0.03	-0.0022	-0.10
Panel C: Overnight repo against CMB collateral									
CMB-collateralised repo volume	**1.00**	**0.6542**	**7.91**	0.08	-0.0263	-0.24	0.03	-0.0005	-0.09
CMB-collateralised repo - ON tgt rate	**0.91**	**0.0287**	**1.51**	0.07	0.0057	0.22	0.03	0.0002	0.13
CMB-collateralised repo haircut	0.03	0.0023	0.08	0.03	0.0084	0.09	**1.00**	**0.4252**	**7.75**
Prov-collateralised repo - ON tgt rate	**0.81**	**-3.1325**	**-1.20**	0.02	-0.0064	-0.01	0.04	-0.0261	-0.12
Prov-collateralised repo haircut	0.06	0.0035	0.15	0.03	-0.0042	-0.09	**0.91**	**-0.0766**	**-2.28**
1y adj mortgage - Fed funds rate	**0.94**	**-0.1624**	**-2.05**	0.08	0.0265	0.25	0.07	-0.0001	0.00
GoC deposits at BoC	0.03	-0.0018	-0.06	0.03	-0.0189	-0.13	**0.96**	**0.1889**	**2.99**
Financial stress index	0.02	0.0001	0.00	0.04	0.0082	0.12	**0.64**	**-0.0820**	**-1.15**
Panel D: Overnight repo against Provincial collateral									
CMB-collateralised repo volume	0.03	0.0012	0.07	**0.58**	**-0.0023**	**-1.05**	0.17	0.0170	0.40
Prov-backed repo volume	**1.00**	**0.6911**	**9.02**	0.09	-0.0001	-0.24	0.03	0.0002	0.04
Prov-collateralised repo - ON tgt rate	0.09	-0.3212	-0.23	**1.00**	**0.7105**	**10.41**	0.37	-1.4056	-0.69
Prov-collateralised repo haircut	0.04	0.0025	0.11	0.21	-0.0006	-0.46	**1.00**	**0.4837**	**8.23**
3m-1m Bankers' Acceptances rate	**0.74**	**-2.7415**	**-1.22**	0.04	0.0012	0.14	0.03	0.0163	0.09
Bank - 90d deposit rate	0.14	-0.0605	-0.30	0.03	0.0000	0.00	**0.99**	**0.7701**	**3.86**
1y adj mortgage - Fed funds rate	**0.72**	**-0.2536**	**-1.27**	0.19	0.0009	0.41	0.19	-0.0500	-0.42
1y swap spread	0.03	-0.0027	-0.04	0.03	0.0002	0.10	**0.73**	**-0.5755**	**-1.32**
Aaa corp bond - Fed funds rate	0.03	0.0196	0.07	**0.87**	**-0.0743**	**-2.00**	0.02	-0.0011	-0.01
CDOR - OIS spread	0.03	0.0184	0.09	**0.84**	**0.0440**	**1.83**	0.04	0.0245	0.15

Note: Results of the Bayesian Model Averaging analysis for the different types of interbank lending (uncollateralised, GoC repos, CMB repos and Provincial repos) as indicated for each panel. The following statistics are reported for variables that have at least a 50% posterior probability of inclusion for at least one of the terms of trade for the interbank loan type: posterior probability of inclusion, posterior mean, and the ratio of the posterior mean to the posterior standard deviation of the estimate. The BMA analysis is run separately for the three terms of trade – the log of the volume (in billions of Canadian dollars), the spread of the lending rate over Bank of Canada's overnight target, and the haircut applied to the collateral (for repo trades only). Variables that have a posterior probability of inclusion of at least 50% are highlighted in **bold**. The independent variables used in this analysis are described in Table 1 along with their sources.